8-VSB LIKE BACKWARD-COMPATIBLE ROBUST STREAM MODULATION FOR

ATSC DIGITAL TV TRANSMISSION

5   The present invention relates to modifying an American Television Standards Committee (ATSC) digital TV signal in a backward compatible manner to enable broadcasting a signal that has a different degree of robustness together with the existing signal.

The ATSC transmission format for digital television (DTV) uses and 8 level vestigial sideband (8-VSB) technique in which each successive 3 bit symbol is transmitted as one of 8 possible

10   signal amplitudes. There has recently been a growing interest in modifying the ATSC DTV standard in a backward compatible manner so that broadcasters can broadcast a signal that has a different degree of robustness together with an existing signal. The key to achieving robustness in a backward compatible manner lies in the signal processing of the error correction part of the transmitter. A top level diagram of the mixing of a robust stream with a standard stream is shown in FIG. 1.

15   The 8-VSB ATSC standard uses signals mapped to one of the eight levels:

$$(-7, -5, -3, -1, 1, 3, 5, 7).$$

This is called an equiprobable 8-VSB signal. One of the known approaches for encoding a robust

20   stream is to reduce the alphabet size from 8 levels to 4 levels. For example, possibilities exist to use:

{-7,-5, 5, 7},	or
{-7,-1, 3, 5},	or
{-5,-3, 1, 7},	etc.

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When the alphabet size is reduced from eight to four, the performance of the system improves because the distance between permissible signal levels is greater, so that the transmitted signal is less susceptible to noise and distortions. One of the disadvantages of such reduced-alphabet systems is that they potentially have backward compatibility problems. Receivers that are designed based on the

30   eight-level statistics may show some degradation.

Thus there is a need for an approach to transmitting a robust symbol stream in conjunction with a normal stream that is backward compatible.

The system and method of the present invention applies multiple modulation types in a single stream of standard and robust symbols in such a way that the statistics of the output signal look like a

standard 8-VSB signal. If, for example, according to the present invention one of the set of constellation points

$$\{-7,-1, 3, 5\} \qquad \text{or}$$

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$$\{-5,-3, 1, 7\}$$

is randomly selected to modulate each symbol of a robust stream, the average output signal will look like a standard 8-VSB signal because the set union of the 4-level alphabet constellation point sets $\{-7,-1, 3, 5\}$ and $\{-5,-3, 1, 7\}$ is the eight level constellation point set $\{-7,-1, 3, 5,-5,-3, 1, 7\}$.

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FIG. 1 illustrates the mixing a robust stream with a standard stream of a standard ATSC digital TV signal.

FIG. 2 illustrates the constellation diagrams.

FIG. 3 illustrates a simplified top-level diagram of the last stage of an ATSC VSB encoder

15   modified according to the present invention.

FIG. 4 illustrates a high level flow diagram for the part of the last stage of an ATSC VSB encoder modified according to the present invention.

It is to be understood by persons of ordinary skill in the art that the following descriptions are

20   provided for purposes of illustration and not for limitation. An artisan understands that there are many variations that lie within the spirit of the invention and the scope of the appended claims. Unnecessary detail of known functions and operations may be omitted from the current description so as not to obscure the present invention.

Referring now to FIG. 2, if the set of constellation points $\{-5,-3, 1, 7\}$ 201 or $\{-7,-1, 3, 5\}$

25   202, are randomly selected to modulate each symbol of the robust stream in a multiplexed manner, the average signal 203 looks like a standard 8-VSB signal 200.

Referring now to FIG. 3, the constellations are achieved by manipulating the input to the trellis encoder 304 of a standard 8-VSB system 300. For a given robust stream symbol, the control sequence generator 303 instructs the pre-processor 302 to generate the appropriate bits such that when

30   these bits are input to the standard trellis encoder 304, the output of this standard trellis encoder 304 is forced to be one of the desired 8-VSB constellation points.

Thus, the standard trellis encoder device 304 produces a stream of trellis encoded bits corresponding to bits of the multiplexed stream of input bits and additionally maps the trellis encoded

bits into symbols so that multiple modulation types are employed in a single stream in such a way that the statistics of the output signal look like a standard 8-VSB signal.

In the present invention, robust and existing standard bit streams are mixed in a backward compatible manner such that a signal that has a different degree of robustness can be transmitted

5   together with an existing signal thus allowing better reception of ATSC digital TV signals.

Referring now to FIG. 4, a standard stream symbol is received 401 or a robust stream symbol is received 402 and is multiplexed 403 into a single stream and output to a pre-processor 302. A control sequence generator 303 continually monitors and identifies 404 the type of symbol of the multiplexed stream that is entering the pre-processor 302. For each robust symbol identified 405, the

10   control sequence generator 303 instructs the pre-processor to generate appropriate bits 406 to force the standard trellis encoder 304 to output one of the 8-VSB constellation points.

Preferably, the control sequence generator 303 directs generation of bits by the pre-processor 302 that force the standard trellis encoder 304 to produce an averaged constellation 203 that is substantially a standard 8-VSB constellation 200 by randomly selecting one of a pair 201 202 of

15   reduced 4-level alphabets that together average to a standard 8-VSB constellation 203. That is, the resulting data stream contain normal data multiplexed with robust data such that statistics of the data stream are such that it appears to be a standard 8-VSB stream.

Thus, the present invention is embodied in the ATSC-compliant embedding of information bearing symbols in a data stream and creates a more robust tier of service while maintaining backward

20   compatibility with existing ATSC-compliant receivers and transmitters. The four requirements for such backward compatibility with legacy 8-VSB ATSC systems are satisfied by the system and method of the present invention:

1. robust data appears at the receiver to have the characteristics of an 8-VSB signal;

2. robust data uses the existing trellis encoder at the transmitter and the existing trellis

25   decoder at the receiver;

3. robust data generates valid Reed Solomon parity bytes so that existing receivers do not flag robust data as having Reed Solomon parity errors; and

4. robust data maintains the MPEG format and does not destabilize the existing MPEG decoder.

30   While the preferred embodiments of the present invention have been illustrated and described, it will be understood by those skilled in the art that various changes and modifications may be made, and equivalents may be substituted for elements thereof without departing from the true scope of the present invention. In addition, many modifications may be made to adapt the teachings of the present invention to a particular situation without departing from its central scope. For example, the manner

in which the control sequence generator 301 instructs the pre-processor 302 may vary. Therefore, it is intended that the present invention not be limited to the particular embodiments disclosed as the best mode contemplated for carrying out the present invention, but that the present invention include all embodiments falling within the scope of the appended claims.